The background of the entire page is a photograph of 'The Vessel' in New York City. It is a large, multi-level public space with a complex, geometric design of copper-clad walkways and stairs. People are seen walking on various levels. In the background, a modern glass skyscraper and other city buildings are visible under a clear blue sky. A semi-transparent white banner is overlaid on the lower half of the image, containing the title text.

IMOA Annual Review 2018/2019



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IMO A Annual Review

Overview from the Secretary-General



Tim Outteridge
Secretary-General

Our Annual Review reports on progress towards our objectives of promoting the use of molybdenum in new and existing applications and ensuring its regulation is proportionate and based on sound science. The last year has seen some noteworthy achievements.

2019 also marks the end of our five-year strategic planning cycle. A new plan, devised in consultation with our Executive Committee and members, was published in August and is available in the members' area of the website.

Ensuring access to markets through solid science and research

The work of our Health, Safety and Environment Committee is focused on ensuring that decision-making and regulation of molybdenum across the globe is balanced and based on scientifically robust data. This work is vital, ensuring access to markets for our members.

Over the past year, we have seen our strategy of engaging in dialogue with regulators globally and providing sound scientific data pay dividends. At the beginning of 2019, the U.S. State of Oregon de-regulated molybdenum and its compounds from its 'Toxic-Free Kids Act'. This came on the back of a similar successful de-listing in neighboring Washington State during 2017. We are continuing to build our relationships in the U.S. and are currently seeking de-listings in other states.

Our OECD-endorsed molybdate effects dataset was leveraged in several jurisdictions to address water quality standards, resulting in upward revision of the limit values for the protection of aquatic life in Saskatchewan and for the extraction of drinking water in the EU. Similarly, we are seeking to make U.S. regulators aware of the dataset for

setting the limit under the Ground Water Protection Standard for facilities producing coal combustion residues, where currently the value is based on data from 1992.

IMOA generated datasets are also being used to guide Canadian regulators in their Canada Chemical Management Plan and the U.S. Environmental Protection Agency (EPA) in a review of molybdenum substances under the U.S. Toxic Substances Control Act.

In March 2019, IMOA's OECD-compliant, peer-reviewed two-generation reprotoxicity study was published in the 'Journal of Reproductive Toxicology' and will have the keen attention of several authorities in the U.S. and the EU for regulatory purposes.

documents. A key ongoing focus for the REACH Molybdenum Consortium (MoCon) is therefore to make sure we continue to support knowledge on molybdenum and achieve compliance with ECHA policy and REACH requirements. IMOA is also raising awareness of the availability of technical data to help the Korean molybdenum industry achieve K-REACH compliance.

Promoting the value of molybdenum in existing and new applications

Raising the profile of molybdenum amongst engineers, architects and specifiers and making them aware of its utility is a key activity for IMOA. The Market Development Committee has continued to build awareness of molybdenum and

Reproductive Toxicology 84 (2019) 75–92

Contents lists available at ScienceDirect

Reproductive Toxicology

journal homepage: www.elsevier.com/locate/reprotox

A two-generation reproductive toxicity study of sodium molybdate dihydrate administered in drinking water or diet to Sprague-Dawley rats

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Following a two-year project, the Life Cycle Inventory dataset for molybdenum products for metallurgical applications was published in December 2018, and is now supported with a program of five-yearly updates.

Regarding REACH, the European Chemicals Agency (ECHA) is stepping up its requirement for data dossiers to be regularly updated and remain living

promote its properties and effects in steel and stainless steel alloys, delivering real and ongoing benefits for members.

In the carbon steel sector, we have supported the use of molybdenum through visits to steelmakers, as well as organizing events and seminars. Direct benefits have also been realized from research and development projects. Successful projects with leading steel

producers and research institutes have already led to increased molybdenum use. Further projects are underway, including the European STROBE project to optimize design with stronger steels in construction.

This year, we increased engagement with steel producers in the U.S. to promote the benefits of molybdenum in advanced steel grades for automotive applications and continued the work in Europe, China, Japan and Korea to incrementally improve alloy design.

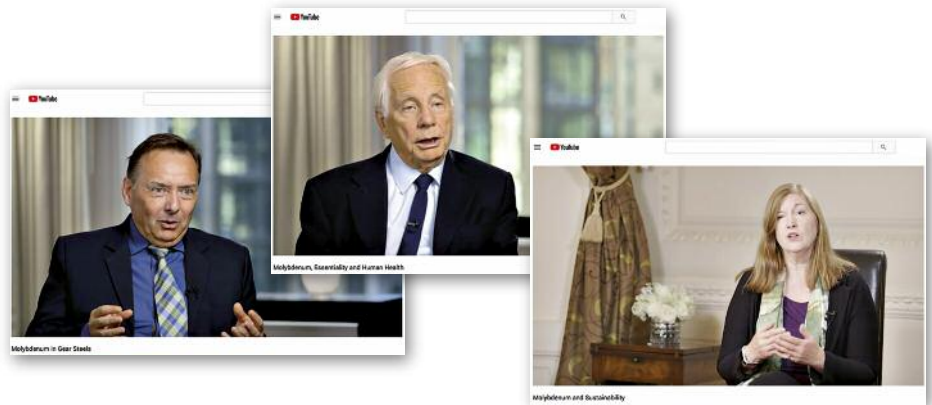
China is a key market for molybdenum where we strive to strengthen our relationships and sphere of influence. In the construction sector, we promote molybdenum-containing stainless steel façades by engaging with the supply chain to foster best practice in design, fabrication and installation.

Our well-established and successful program of work promoting molybdenum-containing stainless steel in the Architecture, Building and Construction (ABC) sector in North America, continues to deliver results for members, through seminars and accredited courses for architects and specifiers.

Our project with the Nickel Institute (NI) and also the International Stainless Steel Forum (ISSF) to promote the use of stainless steel water service piping to tackle the global problem of drinking water loss through leakage has gained traction in the last year, with many more interested parties and a pilot installation in place.

Support for the structural stainless steel sector also gathered momentum as we worked towards the development of an international standard based on the AISC Design Guide published in 2013.

We continue to be a member of 'Team Stainless' alongside other trade



associations, contributing to activities and initiatives across research, communications and standards.

Increasing awareness through communications

Communication activities focused on supporting the market development program and keeping members informed about the ongoing work of the association.

Over the year, we have continued to build upon our successful media outreach program designed to promote the benefits of molybdenum to wider industry audiences. Proactive news releases have generated several articles on topics including global production and use statistics and the new IMOA videos of industry experts explaining the benefits of molybdenum.

Media articles authored by IMOA consultants have appeared in a range of trade media including Stainless Steel World News, Steel Times International and Materials World. These articles, originally featured in MolyReview, promote different uses of molybdenum in a range of diverse applications.

Online communications continued to be at the core of our communications program. The IMOA website attracts over 14,000 visitors on average each month. The social media program has seen an increase of over 18% in the past year. Regular tweets and posts on LinkedIn

drive users to our website and the wealth of high-quality information that is available. A series of blogs, repurposing MolyReview content, is also designed to capture attention and drive traffic to the website. We have significantly increased our online presence in China with the launch of the IMOA WeChat channel. This has received positive feedback and currently has over 1600 followers.

A series of nine videos of IMOA experts discussing the benefits of molybdenum in architecture, building and construction, in the automotive industry and in pipeline steels and the essentiality of molybdenum in everyday life were launched on IMOA's YouTube channel earlier in the year. These provide a wealth of content that can be used in various contexts and will be promoted regularly on the IMOA website and through social media channels.

Keeping members up-to-date with market information

We continue to provide regular market updates for members. Each quarter, we collate and publish global molybdenum production and use statistics in the members' area of the website. A detailed overview of end uses presented at our AGM attracts a large audience. Annual and quarterly summaries are also released to the media and generate regular coverage, underpinning our role as the most reliable source of information on the molybdenum market.

Health, Safety and Environment (HSE)



Sandra Carey
IMOA HSE Executive



“The work of our Health and Safety Committee is focused on ensuring that the regulation of molybdenum across the globe is appropriate and based on sound science. Generating robust scientific data required for regulatory purposes, either to fill data gaps or as weight-of-evidence against existing poor-quality data, is key to that goal.”

Health, Safety and Environment

Key activities and achievements in 2018/2019

IMOA HSE Committee activities

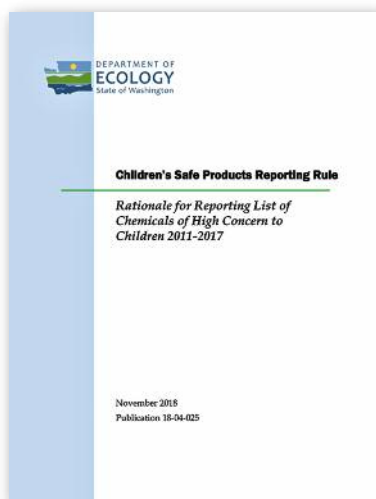
Over the past year, our dialogue with regulators and ability to produce robust data on which their decisions can be based has led to some significant successes.

U.S. Toxic-Free Kids Act

In January 2019, Oregon Health Authority de-regulated molybdenum and compounds from its legislation known as the 'Toxic-Free Kids Act'. De-regulation was a result of a triennial review of substances on their Chemicals of High Concern to Children list, during which IMOA made a technical submission that shared and advocated more recent toxicological and risk assessment data than had been available when the substances were first listed in 2016. Several of the key studies in the submission were ones commissioned by IMOA to independent laboratories, conducted in accordance with stringent OECD protocols, to foster international regulatory confidence in the generated data.

This decision by Oregon State followed a similar success the previous year, in which an IMOA submission resulted in the de-listing of molybdenum and compounds from Washington State's Children's Product Safety Rule in October 2017.

Most recently, in April 2019, we made a similar technical submission to the Minnesota Dept. of Health, to request de-listing of molybdenum from their list of Chemicals of High Concern which is part of their Toxic-Free Kids Legislation. Work surrounding this is currently ongoing.



Meanwhile, similar legislation is being considered for enactment in 2019 in the State of New York. So, we will begin dialogue with the appropriate authorities at the earliest opportunity to make the case, supported by robust science, against listing molybdenum and compounds as substances to be regulated.

Water quality standard in Saskatchewan Province, Canada

Saskatchewan Province, Canada, conducted a two-year review process to determine a revised water quality standard protective of aquatic life. The review resulted in a new value of 30 mg Mo/liter, representing a significant uplift from the original value of 0.07 mg Mo/liter.

The new quality standard was adopted in December 2018. During the review and the public consultation, the Saskatchewan authorities publicly acknowledged our role both as provider of much of the high-quality data, and also for the dataset benefiting from OECD Mutual Acceptance of Data status. (IMOA achieved this OECD MAD status for its molybdate effects dataset in 2014).

As an OECD-member country, this OECD endorsement of the data quality was influential in their consideration and acceptance of the IMOA environmental effects dataset as the basis for a significant part of their quality standard re-assessment. In fact, when determining the new value, all but one of the chronic effects data-points were drawn from our dataset.

EU Water Quality Standards (WQS)

2019 represents a step-change in our work on Water Quality Standards.

S A S K A T C H E W A N

WSA 514 - Saskatchewan Water Quality Objective for the Protection of Aquatic Life - Molybdenum

FACT SHEET

FACT SHEET OVERVIEW

The Water Security Agency is the lead agency for water management in the province. The Water Security Agency has adopted a molybdenum water quality objective for the protection of aquatic life. The Ministry of Environment will adopt this water quality objective in the Saskatchewan Environmental Quality Guidelines.

MOLYBDENUM (Mo)

Molybdenum occurs naturally in the environment. It is a transition metal of Subgroup 6A in the periodic table, and has a molecular mass of 95.96 g/mol. The Chemical Abstracts Service (CAS) number for molybdenum is 7439-98-7. In mineral form, it is primarily observed as molybdenite (MoS₂), however other common forms include powellite (CaMoO₄) and wulfenite (PbMoO₄). It is also found in minerals containing iron, bismuth or copper, and may co-occur with other deposits. It has oxidation states that range between -2 and +6, however under typical environmental conditions molybdenum compounds are primarily in oxidation states ranging between +3 and +6 (Xu *et al.* 2013). The molybdate anion (MoO₄²⁻) is the predominate dissolved form of molybdenum in natural waters

with pH values greater than 6 and is the species most commonly investigated in toxicity tests, typically supplied as sodium molybdate dihydrate (Na₂MoO₄·2H₂O).

The molybdenum water quality objective provides an update on current knowledge of the aquatic toxicity of molybdenum to freshwater organisms. Using these data, a long-term freshwater guideline has been produced using the fifth percentile of the species sensitivity distribution (SSD), following guidance provided in the CCME Protocol (2007). This has resulted in a new Surface Water Quality Objective (SWQO) that has been adopted by the Water Security Agency (WSA) in Saskatchewan for molybdenum in natural waters (Table 1).

Table 1 Surface Water Quality Objectives for the protection of aquatic life for molybdenum developed using CCME Protocol (2007).

	Long-Term Water Quality Objective for Molybdenum (µg/L)	Short-Term Water Quality Objective for Molybdenum (µg/L)
Freshwater	31,000 ¹	NRG ²
Marine	NRG ³	NRG ³

NRG = no recommended guideline
¹ This objective was derived based on total molybdenum concentrations.
² There were insufficient data available to derive a short-term freshwater benchmark with reasonable confidence due to the majority of available effect concentrations representing unbounded data points.
³ Data were not evaluated for marine species.

The work has already been successfully deployed in regulatory discussions, resulting in an increase in the maximum allowable concentration of molybdenum in groundwater in one EU country. We are now converting the report into a manuscript for peer-reviewed journal publication, to facilitate wider dissemination of the data to the regulatory community.

U.S. EPA Mo in Groundwater Protection Standard (GWPS)

We were disappointed to note that in July 2018, the U.S. Environmental Protection Agency (EPA) set a very low GWPS (100 µg Mo/L) for facilities producing coal combustion residues (CCR). Whilst it is not a Maximum Contaminant Level value, but one at which facilities should check if their CCR disposal units are leaking, it is of particular concern because the calculation was based on archaic data. The U.S. IRIS database for molybdenum was last reviewed back in 1992, and therefore benefits from none of the robust data contained in the 2014 OECD MAD molybdate effects dataset for highly soluble molybdenum salts, which is increasingly being used globally by the international regulatory community. We are working with colleagues at NAMC (North American Metals Council) to encourage U.S. EPA to include a pop-up notification within the IRIS database that would alert data-seekers to the existence of more recent data in online sources, such as the OECD Existing Chemicals database where our dataset resides.

Substance Assessment

Substance hazard and risk assessment using reliable and robust scientific data is fundamental to implementing effective chemicals management legislation. Over the last year, we have continued to proactively submit IMO's

Until this year, our contribution to deriving WQS included the generation and provision of molybdate effects datasets relevant to the aquatic environment, to authorities engaged in reviewing existing standards. In recent years, we have also constructively critiqued Mo WQS values proposed by several EU Member States, and

at EU Commission level. 2019 is seeing a significant step-change in our approach, whereby for the first time IMO is deriving the numbers. We recently developed a report that uses EU Water Framework Directive methodologies to determine quality standards for water bodies relevant for drinking water extraction.

datasets into national chemical assessment programs:

Canada Chemicals Management Plan

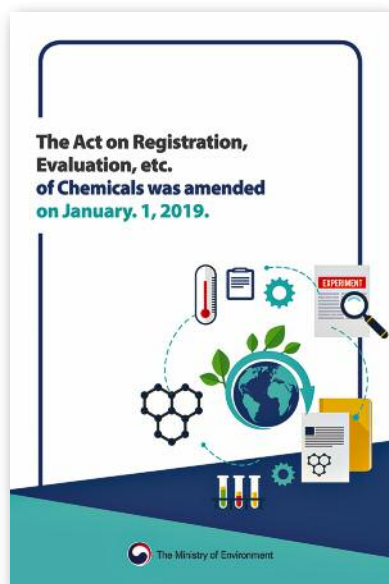
Canada's Chemicals Management Plan (CMP) is now in Phase 3. During this phase, the federal Canadian regulatory authorities, Health Canada and Environment Canada are assessing a series of inorganics, including molybdenum substances. We provided datasets for molybdenum trioxide and molybdenum disulfide. As a result, in summer 2018 they published a 'Science Approach Document for the Ecological Risk Assessment of Inorganic Substances' that proposes a Mo Predicted No Effect Concentration (PNECaquatic) of 26.34 mg Mo/L for the protection of aquatic life (a comparable value to the 31 mg Mo/L approved by Saskatchewan Province).

U.S. Toxic Substances Control Act

Molybdenum and compounds are on the list of 70 substances for assessment under the U.S. Toxic Substances Control Act. We are preparing a data package for submission this year to the U.S. Environmental Protection Agency to facilitate their access to IMO's extensive dataset.

K-REACH

REACH-type chemicals management legislation, similar to EU REACH, entered into force in Korea at the beginning of 2019. The initial step of pre-registration by manufacturers and importers and Only Representatives ended in June. The key phase of data-gathering and hazard/risk assessment will run for registrations due between 2022 to 2027, according to specified tonnage band volumes. Industry is responsible for the data-gathering phase. We have been working to ensure that the Korean molybdenum industry is aware that it can source from IMO



the majority of the necessary technical data to achieve K-REACH compliance.

Peer-reviewed publications

The March 2019 edition of the Journal of Reproductive Toxicology includes a paper about the two-generation reproductive toxicity study using sodium molybdate dihydrate as the test substance. This represents the final step in the >US\$1million five-year undertaking to generate significant new and reliable, OECD-guideline-compliant, science on this critical human health endpoint.

The paper is available via the journal's website as a free Open Access document. The discussion section contains a detailed comparison and rebuttal of the earlier Fungwe 1990 study, previously the only study available for regulatory assessment and use. Several agencies were awaiting finalization and publication of the study for their immediate regulatory purposes, including U.S. EPA Office of Water, U.S. Agency for Toxic Substances and Disease Registry (ATSDR), U.S. EPA

Region 8, and the European Chemicals Agency.

This paper will prove invaluable in future regulatory discussions across the globe and will play an important role in ensuring appropriate regulation of molybdenum.

Life Cycle Inventory Update

An LCI is an inventory of flows from and to nature for a product system. Inventory flows include inputs of water, energy and raw materials, and releases to air, land and water. Companies across many industry sectors are keen to assess the green credentials of their own and competing products, and LCI datasets are an essential part of the assessment toolkit. Data that is more than five years old is increasingly not accepted by LCI practitioners or for uploading to publicly available LCI data platforms. Lack of current LCI data has become another business risk to accessing and maintaining markets. Therefore, IMO has a rolling program of five-yearly updates.

The two-year project to update the Life Cycle Inventory dataset for molybdenum products for metallurgical applications was completed in December 2018. Products assessed were roasted molybdenite concentrates in powder and briquette forms, and ferromolybdenum. A series of four documents were produced, three of which are available to LCI enquirers, and one is confidential to each participating company. All reports underwent a peer-review process. In terms of IMO-member participation, we achieved enhanced global geographic representation through several new participants, including one for the first time from Asia.

In order to ensure that LCI practitioners have ease of access to the molybdenum product data, and therefore do not resort





to using proxy data, the dissemination of the IMO A 2018 LCI datasets will be wider than in previous years. In addition, to being available via enquiry to the IMO A website, the datasets will also be embedded in Gabi, which is one of the most frequently used LCI software programs, and publicly available on the International Reference Life Cycle Data System (ILCD).

REACH Molybdenum Consortium (MoCon)

Despite the May 2018 deadline for final tonnage registration, EU REACH is far from over. A glance through the recent ECHA Programming Document 2019–2022 makes it clear that ECHA is still a hive of activity, with numerous plans that will impact industry.

ECHA shifts focus

While their mission ‘to work for the safe use of chemicals’ remains the same, their focus has now shifted to assessing which of the 95,000 registrations submitted by industry, covering approximately 22,250 substances, will be earmarked for further scrutiny. By 2020, they intend to ‘map the chemical universe’, in terms of identifying which substances can be considered safe and which require further regulatory action because they may be harmful to human health or the environment.

The European Commission, in its second REACH Regulation Review, concluded REACH is effective, but not efficient and that its implementation is lagging behind in meeting its political objectives. Other findings include:

- Severe shortcomings in the chemical safety information submitted by industry, especially with regard to long-term effects on human health and the environment and in relation to uses and exposure
- Need to increase registration dossier compliance levels with information requirements
- Industry knowledge on substances in articles needs to improve, not only to meet REACH obligations, but also to face the challenges coming from the EU’s objectives on the Circular Economy
- Improvement and simplification of extended Safety Data Sheets, evaluation, authorization and restrictions
- The issues requiring most urgent action are: acceleration of evaluation, simplification of the application for authorization process, ensuring a level playing field with non-EU companies through effective restrictions and enforcement and clarifying the interface of REACH and other EU legislation, in particular that on Occupational Safety and Health (OSH) and on waste

Continuous improvement

These findings will result in significant further work for industry. ECHA is keen that all REACH registrants continue investing in enhancing their dossier data quality, be it scientific test data, exposure data, tonnage data, etc. It requires a dossier not to be a static snapshot at the time of registration, but a living document. To achieve this goal, ECHA is currently working on a REACH Implementing Act on Updating that will mandate dossier updating at specific time intervals. In order to ensure REACH data compliance, ECHA has a series of compliance-checking tools and processes at its disposal, including common screening checks, specific endpoint checks, dossier evaluation checks, etc., which can result in ECHA Decisions to which industry must respond within a limited timeframe.



ECHA Board of Appeal

At MoCon, we have responded to common screening and endpoint checks on Ferromolybdenum Slags, pure Molybdenum Trioxide, and Ammonium Octamolybdate, and most recently to a dossier evaluation check on sodium molybdate. With the latter, despite extensive explanations and having demonstrated the absence of risk, we received an ECHA Decision requiring

us to re-do our 1st species Pre-Natal Developmental Toxicity (PNDT) study. This was on the basis that the existing one did not satisfy the REACH standard information requirement for hazard determination, despite it being a protocol-compliant test. Between early 2017 and the end of 2018, MoCon invested significant time and energy in ultimately taking its case (A-006-2017) to the ECHA Board of Appeal in October 2018, seeking to overturn the decision. Our appeal was dismissed by ECHA in December 2018. We therefore have until December 2019 to provide ECHA-compliant hazard determination data for the PNDT endpoint. A key focus of MoCon activity during the past year has been working on further studies to ensure our PNDT data achieves compliance with ECHA requirements. This work will continue over the coming year.

MISA initiative

An ECHA/industry cooperative program has been established to address technical and scientific issues facing the metals and inorganics sectors and to improve the registration dossiers in these sectors. Called the Metals and Inorganics Sectoral Approach (MISA), it builds on the principle of continuous improvement and aims to identify, by the end of 2020, any outstanding REACH and CLP standard information endpoints, as well as further information, supply chain communication or risk management needs for as many substances as possible.

The consensus view of the MoCon Technical Working Group was to sign up to this initiative, and we are therefore participating with our sodium molybdate dossier, which is our read-across substance to our other 11 substance dossiers. To-date MISA encompasses 321 substances from 18 metals consortia.

Dossier updating

Work is ongoing within the MISA initiative to:

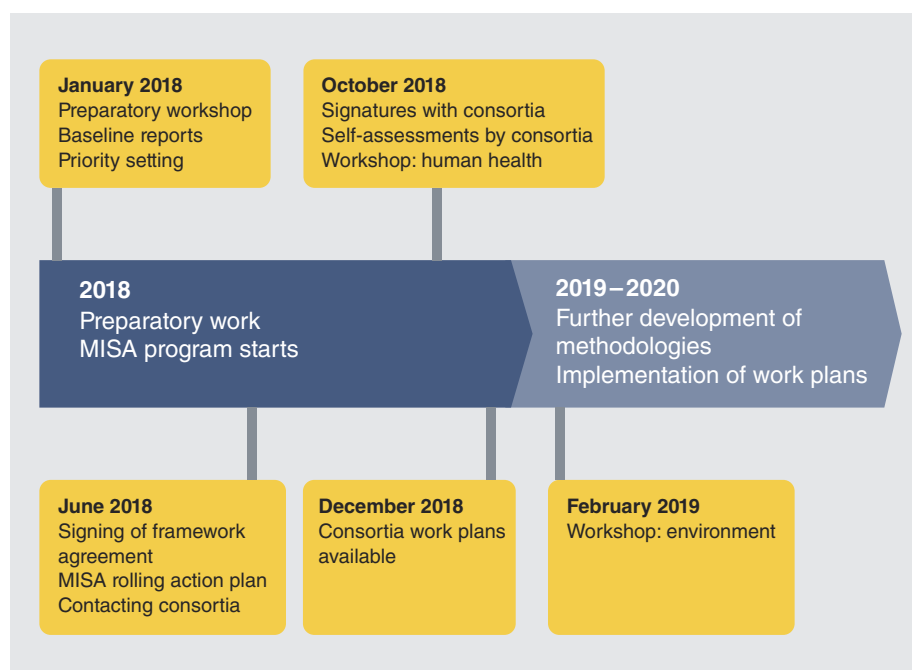
- Enhance some human health endpoints, for example 1st species PNDT and two-generation reproduction toxicity
- Expand the bioavailability dataset from seven to all 12 substances
- Demonstrate how our read-across rationale fits with ECHA's Read-Across Assessment Framework for both human health and environment
- Update the Exposure Scenarios (ES) for molybdenum trioxide (pure and technical grades), moving from a dustiness-based to a task-based approach

We are working for the first time with the Chesar (chemical safety assessment and reporting) tool, as it automatically generates both the Chemical Safety Report (CSR) and the ES. Transitioning to Chesar will speed up the process of future CSR and ES updates, saving on both human and financial resources for

these core activities. We aim to update the sodium molybdate dossier under the MISA initiative, and the other 11 MoCon substances by the end of December 2019. This will be the fourth update of all MoCon dossiers since their initial submission back in 2010/2012, reflecting our commitment to the technical dossier as a 'living document' and not a static snapshot.

The MoCon Steering Committee, Secretariat and Technical Working Group continue to manage the work of the REACH Molybdenum Consortium, seeking to ensure continuing compliance with the EU REACH Regulation No. 1907/2006 for its 61 member companies.


The MoCon and HSE technical activities are managed and driven forward by the corporate members of the respective HSE Committees and MoCon Technical Working Group, the HSE Executive staff member and our technical support service providers. We thank them for their continued dedication and professionalism.



Market Development



Dr. Nicole Kinsman
IMOA Technical Director



“The work of our Market Development Committee focuses on raising the profile of molybdenum and promoting its applications in alloys amongst fabricators, engineers, designers and material specifiers. Our work over the last year has continued to deliver significant benefits to members.”

Market Development

Key activities and achievements in 2018/2019

Carbon steels

The year's activity within our carbon steels program resulted in some 30 visits, events and in-house seminars to support market development. These meetings were focused on disseminating results from IMOA research projects, developing the North American market and increasing activity in China.

Extracting value from research projects

We continued extracting valuable evidence of the beneficial effects of molybdenum in steels from IMOA-funded research to support market development.

The positive results of the welding project with Voestalpine were published

in the highly reputable journal 'Applied Sciences'. The results were also shared with major plate and pipe steel producers in Europe and Asia.

Part of the results from the IMOA direct quench steel project with SSAB Europe were published in the prestigious journal 'Metals'. SSAB itself used the results for optimizing and launching new top-of-the-range steels such as Strenx 1100 plus. Molybdenum contributes to the particularly good welding behavior of this product.

We completed the project on molybdenum-related effects in ultra-high strength press-hardening steel with Okayama University. The results are very favorable and deliver convincing arguments for the use of molybdenum in 1800 and 2000 MPa press hardening steels. A key advantage is that molybdenum significantly increases the resistance to the well-known problem of 'delayed cracking' in these steels. As a result, a major Japanese steelmaker has decided to use molybdenum in a newly developed 2000 MPa press-hardening steel.

A newly developed, molybdenum-alloyed, heavy gage press-hardening steel for truck applications, produced by SSAB Europe, has been running through a validation program at Bruning Tecnometal in Brazil, using specifically developed demonstration dies. Results of this



validation program have been presented at the 'Materials in Car Engineering Conference', Frankfurt, May 2019 and at the '7th International Conference on Hot Sheet Metal Forming of High-Performance Steel – CHS²', Luleå, June 2019.

Focus on North America

We have increased the frequency of visits, discussions and seminars at major North American steel producers. The activities relate to automotive, high-strength structural and special steels. A driving force for the increased interest is the request of steel processing industries to develop the domestic production of specific higher-level steel grades, due to the import tariff situation. Car makers in the U.S. have a particular interest in so-called third generation high-strength steels. Molybdenum brings important benefits to these advanced steel grades. Some of these metallurgical aspects were presented at the 'Great Design in Steels' conference in Detroit, May 2019.

Rest of the world

We made regular visits to leading steelmakers in Europe, Korea and Japan, focusing on continuous and incremental improvement of alloys to better fulfil ever-increasing customer requirements.

Steel Construction Institute Guide

We are also co-sponsoring the preparation of an SCI (Steel Construction Institute, UK) guide on the design and execution of steels of yield strength up to 700 MPa. The guide gives practical and holistic guidance on how to maximize the benefits of high-strength steel, covering a wide range of topics such as design of members and connections, fire resistance and fatigue performance.

Plate with a yield strength of 700 MPa typically contains between 0.1% and



0.4% molybdenum. The development of more cost-effective design rules and simple design tools for these higher strength steels is a strong facilitating factor in growing the market for structures made from these steels.

Market development in China

Over the past year, we have continued to focus efforts on increasing engagement within China.

Promotion of molybdenum-containing special steels

Chinese steel makers produce over half of the world's steel, but China's share of molybdenum use is much lower. Because molybdenum's benefits in special steels are well known and domestic production of these steels is critical to Chinese industry and technology development, there is a great opportunity to expand the market. Therefore, we have worked to disseminate this knowledge through the Shanghai Molybdenum and Steel Symposium and meetings with steel producers and users. We are also expanding our knowledge on molybdenum in gray cast iron in a project with Shanghai University.

Gear steels project

Trial material, developed as part of the IMO A gear steel project by German special steel producer BGH, was shipped to FAST Shanxi Gear Company in Xi'an. FAST processed the material into truck gear components and tested the carburizing behavior. We agreed to begin a specific alloy development with one of their domestic special steel suppliers, working to create a better performing steel that will be suitable for future high-temperature carburizing treatment.

Nanjing Gear Company (NGC), China's largest producer of windmill and heavy machinery gear, is developing and qualifying an improved steel grade according to the guidelines set out by the IMO A gear steel project. The new steel alloy being tested contains an increased addition of molybdenum as compared to their standard grade. Work on this will continue.

Molybdenum and Steel Symposium

IMO A, in cooperation with Shanghai University, organized an international Molybdenum and Steel Symposium last



November in Shanghai. Over 100 experts from the metallurgical and steel using industries participated in this event. Several renowned foreign experts, as well as leading Chinese experts highlighted molybdenum's benefits in flat steels, special steels and castings. A summary of the presented information will be published in a special section in the 'Journal of Advances in Manufacturing'.

Stainless steel in China

To support the promotion of molybdenum-containing stainless steels in Chinese Architecture, Building and Construction, we focused our activities on China's greater bay area (Guangdong, Hong Kong, Macau). Construction activity is very high in this area and the warm climate combined with the proximity to the sea requires the use of corrosion resistant construction materials. We continue to regularly monitor the progress of high-rise building projects to promote stainless steel façades and to offer assistance to curtain wall designers, contractors and manufacturers. The seminar that was run jointly with the Nickel Institute with the support of Tongji University's Architectural Design and Research Institute, was well received by the attendees.

To support the promotion of stainless steels in engineering applications, we attended the 6th China International Duplex Stainless Steel Conference in 2018 in Beijing delivering a presentation 'Common and less well known precautions for the fabrication of duplex stainless steels'. A series of welding workshops in Wuhan, Zhuhai and Wuxi, delivered jointly with the Nickel Institute, helped improve the understanding and success rate of welding molybdenum-containing stainless steels and nickel alloys.

We have commissioned a study on the 'Survey of wet Flue Gas Desulfurization (FGD) and corrosion of coal-fired power plants in China'. Working together with

the Nickel Institute, the project aims to better understand the potential for the use of high-performance stainless steel in FGD plants. The units are prone to severe corrosion and could benefit from the superior corrosion resistance of high performance, molybdenum-containing stainless steel. This study aims to report its findings in 2020.

We recognize the importance of increasing engagement within China. Our Chinese IMO A WeChat account, launched in March 2018, has been very well received, with over 1600 followers and new information posted every week.

Architecture, Building and Construction (ABC)

Work has continued to build on the success of the long running program to promote the benefits of molybdenum-containing stainless steel in ABC.

Delivering stainless steel workshops

IMO A has nine courses accredited by the American Institute of Architects (AIA) which provide architects and engineers with continuing education credit. All but one qualify for sustainable design (Health, Safety and Welfare) continuing education credit. In North America, IMO A and the Nickel Institute jointly sponsored a presentation at the prestigious Building Enclosure Council Symposium (Portland). Additionally, building and construction workshops and project meetings were given at some of the world's most influential architecture and engineering firms in Seattle, Pittsburgh, New York and at a Pittsburgh Construction Specifications Institute meeting.

Bridge presentations were given at the Virginia Transportation Research Board and Virginia Department of Transportation, to promote structural use

of stainless steels. Furthermore, efforts were made to increase viewing of the recorded 2017 bridge webinar and the AISC Design Guide 27 webinar, and to distribute the handouts of these webinars to bridge engineers.



In total, the live events attracted about 550 attendees from over 190 companies. U.S. architects and engineers play a major role in global design and construction. The ongoing interaction provided by these face-to-face workshops builds and strengthens relationships, influences global projects and has actively increased the use of molybdenum-containing stainless steel in building and construction in North America and elsewhere.

Over the next planning period, we will be looking to expand this successful program of work to other markets, including China and India.

Publications and articles

The jointly-developed IMO A and NI ABC Stainless Steel Library, which was updated in December 2017, increasing the content to over 550 PDFs, has been distributed to a total of more than 6,700 industry decision makers globally, including to participants at NI-sponsored ABC workshops in Singapore, Malaysia and India in late 2018. Feedback from architectural and engineering firms confirmed that this comprehensive library is highly valued.

Structural market development

Market development for structural stainless steel, including the promotion of the AISC (American Institute of Steel Construction) 'Design Guide 27: Structural Stainless Steel (DG 27)', is an important activity. IMO's consultant, Catherine Houska, gave technical support to many structural projects during the past year. These included two large U.S. vehicular, two potential U.S. pedestrian, and Indian rail and vehicular bridges. Support was provided to the U.S. Army Corp of Engineers in their assessment of duplex stainless steels for a new sea and brackish water lock and dam design. Assistance was also provided on numerous structural high-profile building and sculpture projects.

In addition to the Virginia bridge workshops mentioned above, IMO and NI co-sponsored substantial technical support related to their research on

stainless steel for bridge applications, including technical input on the final report of the findings.

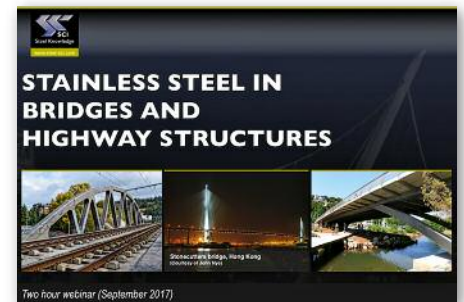
Team Stainless

IMO continues to be a member of Team Stainless, formed from the global trade associations of the stainless steel and alloying element industries to promote the benefits of stainless steel. Notable activity during the year included:

Structural stainless steel communication

The Steel Construction Institute (SCI), as consultant to Team Stainless, carried out a range of promotional activities aimed at educating structural engineers about the economic and long-term benefits of using stainless steel. Nancy Baddoo, Associate Director at SCI, gave a presentation on duplex bridges in a lively session at the Spring IABSE (International Association for Bridge and

Structural Engineering) Conference in Portugal. She also prepared an article promoting the use of stainless steel in structural applications, due to be published in the popular American magazine *Modern Steel Construction* in August 2019. Finally, SCI developed a website to disseminate resources on the use of stainless steel in bridges and highway structures, including a recording of the U.S. Bridge Webinar presented to North American Departments of Transportation (www.steel-stainless.org/bridges) in 2017.



Structural stainless steel standard and specification development

In order to simplify the specification of stainless steel, a strength class system has been developed, initially for introduction in the stainless steel Eurocode, and then into the American specification.

Back in 2007, IMO started lobbying for the development of a mainstream U.S. design specification for hot-rolled and welded structural stainless steel. As a result, the AISC Design Guide (DG27) was published in 2013. It was prepared by consultants and co-financed by a consortium of stainless steel companies and associations. This was followed by the publication of Structural Stainless Steel Design Tables in 2017. Then in 2018, AISC announced that they were converting and expanding DG27 into a



full ANSI (American National Standards Institute) design specification and our consultants are preparing the first draft of the specification.

In parallel with this, the American Society of Civil Engineers is also updating its design specification for lightweight cold-formed structural stainless steel (SEI/ ASCE 8-02), and Team Stainless consultants are on the drafting committee, ensuring the rules balance economy with ease-of-use and that the stainless steel industry is represented accurately and fairly in terms of grades, product availability and other issues.

Both specifications will be ICC (International Code Council) approved, leading to instant acceptance in building and construction codes in much of the world, hence removing barriers to a large potential market. In addition to AISC and Team Stainless, several stainless steel companies contribute to the funding of these industry-wide projects.

Water service pipe project

Many utilities in all regions of the world lose 30% or even more of their freshly treated drinking water between the treatment plant and the consumer tap. Most of the loss occurs in the service pipe which connects the water main under the road to the water meter on each property. Aging infrastructure, urbanization, climate change and extreme weather events all contribute to the pressure on water utilities to reduce leakage and improve network resilience.

The water service pipe project, run together with the Nickel Institute, with contributions from the International Stainless Steel Forum (ISSF), is helping to introduce a leak-resistant, Type 316 stainless steel piping solution to address this increasingly important issue. This proven solution has helped Tokyo, Seoul

and Taipei and other cities in the region to save large amounts of drinking water. The first two cities that have replaced close to 100% of their service pipe with stainless steel have reduced their water loss through leakage to only two to three percent, and Taipei, twelve years into its 20-year replacement program, has reduced its leakage rate from 27% in 2005 to 14% in 2017.

Our joint work includes workshops, conferences and meetings with engineering firms, water authorities, associations, research institutes, installers and suppliers in the U.S.,

for the service pipe and the necessary fittings.

Research projects

We are sponsoring part of the SCI's role in a three-and-a-half-year collaborative European research project called STROBE (Stronger Steels in the Built Environment). The project seeks to overcome specific obstacles to the wider use of high-strength steel (up to 700 MPa yield strength) in construction, primarily focusing on ductility, stability and dynamic response. Partners include three European universities,



Canada, Australia, China, India, UK, Italy, France and Belgium. As a result, we have had the first pilot installation in Australia in late 2018, with more planned. Water authorities in China, the U.S., Canada and the UK are also interested in testing the pipe, and we are working with them to prepare these trials. Simultaneously, we are working on drafting standards in China and the U.S. and on encouraging the establishment of local supply chains

the steel producer Dillinger and the global construction company Hochtief.

The research project on synergistic effects of molybdenum and niobium in high-strength medium carbon quenched and quenched and tempered steels with the Spanish research center CEIT and a German steel producer is ongoing. It studies the effects of processing parameters and composition on the properties of these steels.

Financial Report 2018

Income and expenditure account

For the year ended 31 December 2018

IMOA/Molybdenum Consortium

	2018 \$	2017 \$
Turnover	3,347,030	2,829,181
Operating and administrative expenses	3,019,157	2,888,246
Operating surplus/(deficit)	327,873	(59,065)
Other interest receivable and similar income	25,551	12,088
Surplus/(deficit) on ordinary activities before taxation	353,424	(46,977)
Tax on surplus/(deficit) on ordinary activities	4,480	3,867
Surplus/(deficit) on ordinary activities after taxation	348,944	(50,844)

Balance sheet

For the year ended 31 December 2018

IMO A/Molybdenum Consortium

	2018		2017	
	\$	\$	\$	\$
Fixed assets				
Tangible assets		15,584		20,976
Current assets				
Debtors	155,333		128,164	
Cash at bank and in hand	3,606,074		3,380,821	
	3,761,407		3,508,985	
Creditors – amounts falling due within one year	(664,238)		(766,152)	
Net current assets		3,097,169		2,742,833
Total assets less current liabilities		3,112,753		2,763,809
Reserves				
Profit and loss account		3,112,753		2,763,809
Accumulated funds		3,112,753		2,763,809

Financial commentary

The 2018 audited accounts presented here are consolidated figures for IMO A and the Molybdenum Consortium and are subject to approval at the 2019 AGM. Income from subscriptions and other revenue amounted to US\$3,347,030. After expenses of US\$3,019,157, a surplus (after taxation) of US\$348,944 was carried forward bringing the combined accumulated funds to US\$3,112,753. Of this US\$2,183,442 was attributable to IMO A and US\$929,311 to the Consortium.

In the case of IMO A, improved income and below-budget expenditure resulted in a surplus accruing to the reserves, however the year-end balance remained below the Executive Committee's longer-term objective. The Molybdenum Consortium reserves will contribute to funding the Consortium's essential activities around reprotoxicity testing, standard information requirements and maintaining dossier compliance.



INTERNATIONAL MOLYBDENUM ASSOCIATION
THE VOICE OF THE MOLYBDENUM INDUSTRY



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